CHARACTERIZATION OF DEPOSITED LAYER AFTER ELECTRICAL DISCHARGE COATING (EDC) PROCESS

NORHAZERATUL BINTI MOHAMMAD ZAINUDIN
B051610170

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2021

CHARACTERIZATION OF DEPOSITED LAYER AFTER ELECTRICAL DISCHARGE COATING (EDC) PROCESS

This report is submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for Bachelor Degree of Manufacturing Engineering (Hons.)

by

NORHAZERATUL BINTI MOHAMMAD ZAINUDIN

B051610170

950120-13-6228

FACULTY OF MANUFACTURING ENGINEERING

2021

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

Tajuk: **CHARACTERIZATION OF DEPOSITED LAYER AFTER ELECTRICAL DISCHARGE COATING (EDC) PROCESS**

Sesi Pengajian: **2020/2021 Semester 1**

Saya **NORHAZERATUL BINTI MOHAMMAD ZAINUDIN (950120-13-6228)**

mengaku membenarkan Laporan Projek Sarjana Muda (PSM) ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.

☐ SULIT (Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysiasebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972)

☐ TERHAD (Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/ badan di mana penyelidikan dijalankan)

☑ TIDAK TERHAD

Disahkan oleh:

hazera

Alamat Tetap:
626 Kampung Baru,
97000 Bintulu,
Sarawak

Tarikh: 8 Februari 2021

Cop Rasmi:
ASSOC. PROF. DR. LIEW PAY JUN
Faculty of Manufacturing Engineerir
Universiti Teknikal Malaysia Melaka

Tarikh: 8 Februari 2021

*Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.

DECLARATION

I hereby, declared this report entitled "Characterization of Deposited Layer After Electrical Discharge Coating (EDC) Process" is the result of my own research except as cited in references.

Signature	: ………………………………………
Author's Name	: NORHAZERATUL BINTI MOHAMMAD ZAINUDIN
Date	: 8 Februari 2021

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirement for Degree of Manufacturing Engineering (Hons). The member of the supervisory committee is as follow:

ASSOC. PROF. DR. LIEW PAY JUN
Faculty of Manufacturing Engineerin
Universiti Teknikal Malaysia Melaka

…………………………………………………

(Prof. Madya Dr Liew Pay Jun)

ABSTRAK

Dalam industri, aluminium siri 6000 digunakan secara meluas dalam pembuatan mesin pengacuanan kerana sifatnya yang unik. Ianya mempunyai nisbah kekuatan dan berat yang hebat, pengalir elektrik yang baik, tahan pada hakisan dan kerosakan dan juga mudah diubah bentuk. Walaupun aluminium mempunyai ketahanan daripada hakisan dan kerosakan, dalam beberapa jangka masa, kualitinya akan menurun. Dalam kajian ini, pengubahsuaian permukaan aluminium 6061 telahpun dilakukan dengan menggunakan Lapisan Pelepasan Electrik (EDC) dengan penggantungan serbuk atau Permesinan Campuran Serbuk Lepasan Elektrik (PMEDM). Nilai purata saiz zarah dan morfologi serbuk tungsten (W) dicirikan dengan menggunakan Scanning Electron Microscopy (SEM) dan kesan arus puncak (Ip) serta nadi tepat waktu (T_{ON}) pada ketebalan lapisan dikaji selepas proses EDC. Serbuk W telah digunakan sebagai bahan tambahan dalam minyak tanah dengan parameter Ip yang dipelbagaikan pada 3A dan 4A dan T_{ON} pada 150 µs, 200 µs dan 250 µs, manakala parameter yang lainnya seperti voltan yang dilepaskan (V), kepekatan serbuk (g/L) dan waktu permesinan adalah tetap. Mesin Sodick AQ35L die sinker digunakan untuk menjalankan proses EDC. Batang elektrod digilap dan dibersihkan terlebih dahulu untuk mendapatkn permukaan yang rata pada pangkalnya dan penyediaan campuran bahan bendalir sebelum eksperimen dijalankan. Setelah eksperimen siap dijalankan, ketebalan lapisan dikaji. Keputusan yang diperolehi menunjukkan purata saiz serbuk adalah pada 1.29 µm dan mempunyai bentuk yang tidak tetap. Selain daripada itu, lapisan yang paling nipis ditemui pada 3A, 150 µs dengan purata ketebalan adalah sebanyak 6.724 µm, manakala lapisan yang paling tebal dengan purata ketebalan sebanyak 17.239 µm ditemui pada parameter 4A, 250 µs. Kesimpulannya, nilai Ip yang tinggi dan jangka masa T_{ON} yang panjang meningkatkan ketebalan lapisan.

ABSTRACT

In industry, aluminium 6000 series is widely used for fabrication of mold and die due to its unique characteristic. It has a great strength-to-weight ratio, good conductivity, resistance to wear and corrosion and also easy to form. Although aluminum is resistance to corrosion and wear, after some duration of time, it will degrade. In this research, surface modification of aluminium 6061 was carried out by using electrical discharge coating (EDC) with powder suspension or powder mixed electrical discharge machining (PMEDM). The average particle size and morphology of tungsten (W) powder was characterized by using Scanning Electron Microscopy (SEM) and the effect of peak current (Ip) and pulse on time (TON) on the coating layer thickness were investigated after the EDC process. W powder was used as an additive in the kerosene oil and the parameters of Ip were varied at 3A and 4A and TON at 150µs, 200 µs and 250 µs, while the other parameters such as discharge voltage (V) and powder concentration (g/L) and machining time remains constant. Sodick AQ35L die sinker machine was used to run the EDC experiment. Electrode was polished and clean first to get a flat surface on the base and the preparation of mixture was done before the experiment run. After the experiment, thickness of coating layer was investigated. The result shows that the average particle size of W powder is 1.29 µm and in irregular shape. On the other hand, thinnest coating layer was observed at 3A, 150 µs with the average value 6.724 µm, while thickest coating layer with the average value 17.239 µm was observed at parameter 4A and 250 µs. As a conclusion, a high value of Ip current and longer duration of TON increased the thickness of coating layer.

DEDICATION

I would like to dedicate my work to my beloved husband, Mohd Hisyamuddin Bin Mohd Zin, my lovely father and mother Mohammad Zainudin Bin Abdul Kadir and Tamah Binti Lazim for their support, understanding and encouragement along the journey to finish this report.

Not forgotting my sweet little boy, Muhammad Asyraf Hardy Bin Mohd Hisyamuddin for always make my days bright and happy. Although there is a lot of obstacle and need to face a lot of pressure, their existence in my life make me realize that family is always the best listener and du'a from all of them is the bridge for my to success.

Thank You So Much & Love You All Forever

ACKNOWLEDGEMENT

In the name of ALLAH, the most gracious, the most merciful, with the highest praise to Allah that I manage to complete this final year project successfully without difficulty.

Thank you to my respected supervisor, Professor Madya Dr Liew Pay Jun for the great mentoring that was given to me throughout the project. Besides that, I would like to express my gratitude to my beloved supervisor for kind supervision, advice and guidance as well as exposing me with meaningful experiences throughout the study.

Last but not least, I would like to give a special thanks to my best friends who gave me much motivation and cooperation in completing this report especially to Amyliana binti Mahasaan, Nudra Syafina binti Yazid that always give me moral support and Yap Ching Yee that always give me useful advice and many information for my research. Thanks for the great friendship.

Finally, I would like to thank everybody who was important to this PSM report, as well as expressing my apology that I could not mention personally each one of you.

TABLE OF CONTENTS

LIST OF TABLE

LIST OF FIGURES

LIST OF EQUATION

LIST OF ABBREVIATIONS

UTeM	-	Universiti Teknikal Malaysia Melaka
FKP	-	Fakulti Kejuruteraan Pembuatan
FKM	-	Fakulti Kejuruteraan Mekanikal
EDC	-	Electrical discharge coating
PMEDM	-	Powder mixed electrical discharge machining
SEM	-	Scanning Electron Microscopy
XRD	-	X-Ray Diffraction
PSA	-	Particle Size Analyzer
EDM	-	Electrical Discharge Machining
EDX	-	Energy Dispersive X-R
PVD	-	Physical Vapor Deposition
CVD	-	Chemical Vapor Deposition
RTM	-	Resin transfer moulding
SEM	-	Scanning electron microscope
PM	-	Powder metallurgical
TiC	-	Titanium carbide
Al_2O_3	-	Aluminium oxide
NbC	-	Niobium carbide
Si	-	Silicon
OHNS	-	Oil Hardening Non-Shrinkable
HC-HCr	-	High Carbon High Chromium
Al	-	Aluminium
Cu	-	Copper
Cr	-	Chromium
Mo	-	Molybdenum
SR	-	Surface roughness
MRR	-	Material removal rate
TWR	-	Tool wear rate
YZP	-	Yttria-Stabilised Zirconia Polycrystal

PVC	-	Polyvinyl Chloride
TaC	-	Tantalum carbide
W	-	Tungsten
Fe	-	Iron
hBN	-	Hexagonal boron nitride
W-Cu	-	Tungsten and copper
Mg	-	Magnesium
R&D	-	Research and development

LIST OF SYMBOLS

cm	-	Centimetre
m	-	Metre
%	-	Percent
g/cm^3	-	Grams per centimetre cube
wt. %	-	Weight percent
mm	-	Millimetre
MPa	-	Mega Pascal
GPa	-	Giga Pascal
°C	-	Degree Celsius
nm	-	Nanometre
kg.cm3	-	Kilogram centimetre cube
phr	-	Part per hundred resin
kg	-	Kilograms
mm/min.	-	Millimetre per minute
rpm	-	Revolution per minute
Ip	-	Peak current
T_{ON}	-	Pulse on time
T_{OFF}	-	Pulse off time
V	-	Voltage
HV	-	Vickers hardness
A	-	Ampere
µs	-	Micro second
g/L	-	Gram per litre
µm	-	Micro meter
cm^3/L	-	centimetre cube per litre
BHN	-	Brinell hardness number
nA/ cm^2	-	Nanoampere per square centimeter
$\Omega\ cm^2$	-	Ohm per centimetre square
mm/year	-	Millimetre per year

mg/min	-	Milligram per minutes
kgf	-	Kilogram-force
ksi	-	Kilo pounds per square inch
psi	-	pounds per square inch
L	-	Litre
HK	-	Knoop hardness
HRC	-	Rockwell hardness
$Mpa\sqrt{m}$	-	Mpa per square metre
G/Cm^3	-	Grams per cubic centimetre
W/ Mk	-	Watts per metre kelvin
J/Kgk	-	Joule per kilogram per kelvin
ΩCm	-	Ohm centimeter
Kgf/mm^2	-	kilogram force per square millimeter

CHAPTER 1

INTRODUCTION

1.1 Research Background

Surface modification or also known as surface treatment is not a new process in industry. It is widely used not only in engineering field, but also biomedical, automotive and aerospace (Mussada & Patowari, 2015). The main function of surface modification is to change and enhance the chemical, mechanical and physical properties of the material. According to Oshida (2013), by going through the surface modification process, the material not only can improve the wear resistance, but also resistance again degradation, biocompatibility, and surface wettability, this statement also supported by Shibe & Chawla (2014). In this modernization era, there are a few different technique that can be used in surface modification, which are Electrical Discharge Machining (EDM), thermal spraying, Physical Vapor Deposition (PVD), Chemical Vapor Deposition (CVD), Electroplating, Laser coating, Electron-Beam Irradiation and Sputtering (Richhariya, 2013).

EDM is a non- conventional process which is used extensively in industry for machining various conductive material with geometrically shape including difficult-to-cut material (Nanimina et al., 2014). Erosive effect of EDM firstly invented by English scientist, Joseph Priestly in 1770. In EDM, electrical energy is transformed into thermal energy and the energy is used for machining purposes (Khan & Hameedullah, 2011). A series of distinct electrical discharge are produced between the electrode and the workpiece. Electrical discharge sparking between the tool electrode and workpiece and cause the material on the substrate removed (Watane, 2017).

Surface modification of workpiece by material transfer during EDM process is known as Electrical Discharge Coating (EDC) process which is also known as a reversed method of EDM. Watane (2017) mentioned that EDC is one of the evolving coating process due to its comfort, usability, simplicity, reliability and cost effectiveness. Surface coating is used to enhance the properties of the material, not only increasing the strength but also increase the corrosion resistance and wear resistance. EDC is a recent technology where the polarity is reversed, whereas the electrode is connected to anode and workpiece is connected to cathode (Khan & Hameedullah, 2011). In EDC, there are many ways to perform surface modification such as EDC with powder metallurgical electrodes, EDC with multi-layer electrode, EDC with powder suspension or powder mixed electrical discharge machining (PMEDM) and dry EDC (Liew et al., 2020).

In this study, we focus on the PMEDM. The performance of EDM is improved by mixing the powder into the tank that contain dielectric fluid (Nanimina et al., 2014). This process is carry on by mixing electrically conductive powder into the dielectric fluid. An energized powder particles moving and behave in zig-zag movement, then the particle will organize in chain shape and assist the bridging effect that increase the gap voltage and insulating strength of dielectric fluid (Talla, 2016).

In previous research, there are many type of powders have been used such as aluminium, graphite, silicon (Talla, 2016), chromium, copper (Fong & Chen, 2005) and etc. However, the usage of tungsten powder is rarely used in surface modification of aluminium. Therefore, the objective of this study is to investigate the effect of different peak current (I_p), pulse on time (T_{ON}) and discharge voltage (V) of tungsten powder on the characteristic of coated surface including the thickness of deposited layer and elemental composition after the EDC process.

1.2 Problem Statement

In industry especially automotive, aerospace and engineering field, aluminium is used widely due to the properties of the material. According to Karthi et al. (2018) aluminium is a kind of material that have a good conductivity, resistance to corrosion, have high thermal conductivity and light weight. Among the common metal, aluminium is the lightest metal which is three time less than steel metal (Vargel, 2004).

According to Kalpakjian et al. (2018) in fabrication of mold and die, aluminium 6000 series was commonly used. However, after some duration of time, the existence of wear and corrosion on the surface of workpiece will create defect and reduce its service life. The exposure to loads, pressure and extreme temperature during the operation of mold and die, became the main cause to the corrosion of metal (Akpan & Offiong, 2013). Therefore, deposition of material or coating is needed to cover the surface of mold an die in order to prevent it from corrode and wear which can lead to serious damage (Liew et al., 2018). Modification of aluminium surface not only can increase the hardness and thickness of coating layer of the material, but also can increase the life span which is a good investment for manufacturer to save cost (Iqbal et al., 2010).

In this study, surface modification of aluminium was carried out by using W powder suspension. EDC process was used and the peak current (I_p) and pulse on time (T_{ON}) of EDM machine were varied. The thickness of coating layer on the coated surface were investigated after the experiment.